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CONCEPTUAL REMEDIATION PLAN

**COOS BAY BROWNFIELD PILOT PROJECT
Front Street Urban Renewal and Development
Waterfront Heritage District**

April 2003

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1.0 INTRODUCTION

This conceptual remediation plan has been prepared on behalf of the City of Coos Bay as part of the Brownfield Development Pilot Project for Front Street urban renewal and redevelopment in the Waterfront Heritage District. The Waterfront Heritage District includes both publicly and privately owned properties in downtown Coos Bay, Oregon. In December 1998, a *Front Street Master Plan* was developed by the City of Coos Bay Urban Renewal Agency. The ultimate goal of the Master Plan was for redevelopment and economic revitalization of the Waterfront Heritage District.

The City of Coos Bay retained URS Corporation (URS) in June 2000 to perform a series of Phase I and Phase II Environmental Site Assessments (Phase I and Phase II ESAs), and a conceptual remediation plan. This work was funded as a pilot project by a grant from the United States Environmental Protection Agency (USEPA) as part of the Brownfields Economic Redevelopment Initiative. ESAs are typically conducted at Brownfield sites as an initial step to assess the potential that environmental contamination exists. If contamination is identified, the next step typically involves the following:

- Complete a site characterization to determine the nature and extent of the contaminants.
- Assess the threat the contamination poses through the risk assessment process.
- Evaluate potential cleanup options and costs through a feasibility study.

Based on the findings of the site assessment work, conceptual approaches for remediation of environmental contamination identified in the study area have been developed. These concepts are preliminary because a complete evaluation of the site has not been completed, and will need to be reevaluated once the site characterization, risk assessment, and feasibility studies are complete.

1.1 PURPOSE OF THE REPORT

The purpose of this report is to utilize the qualitative and quantitative data collected from the Phase II ESA activities and identify data gaps, possible environmental threats within the study area, and suggest a roadmap to management of impacted areas. This document provides planning-level alternatives for the environmental cleanup of the contaminants and the impacted media identified in the Phase II ESAs.

2.0 SITE DESCRIPTION

2.1 LOCATION AND LAND USE

The Waterfront Heritage District (hereinafter referred "the District") is located in the western portion of Section 26, Township 25 South, Range 13 West, Willamette Meridian, in the City of Coos Bay, Coos County, Oregon (Figure 1). The District is situated at an approximate elevation of 15 feet above mean sea level (msl), as shown on the Coos Bay, Oregon Quadrangle, 7.5 Minute Topographic Series, United States Geological Survey (1971). The topography of the District is relatively flat. The topography of the City of Coos Bay is relatively hilly, with slopes trending from the west to east (towards Coos Bay). The Waterfront Heritage District covers an area of approximately 15 acres along the Coos Bay waterfront. The District is generally bounded by North Bayshore Drive (to the west), Coos Bay (to the east), Fir Avenue (to the north), and Market Avenue (Figure 2).

The District is located within the City of Coos Bay and has historically been developed for various light industrial and commercial uses since the mid-1800's. Property use at the Waterfront Heritage District has historically been related to (mainly) wood products, fishing, metal machining and fabrication, and marine support services including homeports for tug and barge companies. Several sites within the District are identified in Oregon Department of Environmental Quality (DEQ) databases as having environmental conditions or historical environmental conditions.

Currently, the District is used primarily for commercial and industrial purposes. Businesses include business equipment sales and service, repair services, a scrap yard, and towboat homeport facilities.

2.2 SURFACE WATER CHARACTERISTICS

The closest surface water body to the subject property is Coos Bay; several properties along a five block strip front the bay. The majority of the District is covered by improvements including building or pavement. Minor vegetative cover is present in the area, and is generally limited to landscaped plots. In areas without buildings or pavement, stormwater infiltrates directly to the ground surface or flows off site to nearby catch basins. In the paved areas, stormwater flows as surface runoff to the adjacent city streets or flows eastward towards Coos Bay. Surface water along city streets drain to the City of Coos Bay storm sewer system via in-street storm drains. The storm sewer discharges to Coos Bay.

2.3 GEOLOGY AND HYDROGEOLOGY

The City of Coos Bay is situated on the western edge of the Coast Range Mountains of Oregon, a long narrow belt of mountains and coastal headlands. Locally, the City is situated within the Coos Basin, a structural sub-basin of the Coast Range physiographic province (Orr, et. al., 1992).

The native soil and fill at the District are likely underlain by an upper member of the Coaledo Formation. This formation consists of a coarse to fine grained, hard, deltaic sandstone with interbedded siltstones and locally interbedded conglomerate and coal beds. The unit may be greater than 500 feet thick beneath the District.

Soil beneath the District is mapped as Udorthents, which is a U.S. Department of Agriculture (USDA) designation for soils typically found on flood plains, marshes, and tidal flats along streams, estuaries, or bays. The areas have typically been filled and leveled for commercial or industrial use (USDA, 1989). This soil unit consists of sandy, silty, or clayey native soils or dredge spoils, wood chips, and dune sand placed along marsh and tidal flats. Permeability, runoff characteristics, and erosion hazards vary locally (USDA, 1989).

No groundwater monitoring wells were constructed during the Phase II ESA work. Therefore, groundwater flow direction and gradient were not determined. Shallow groundwater was encountered during the Phase II ESA subsurface explorations at depths ranging from 5 to 11 feet below the ground surface (bgs). Based on observations of the local site topography, and the presence of Telegraph Hill immediately west of the site, groundwater likely flows to the east and discharges into Coos Bay. The depth to groundwater and groundwater flow directions are expected to vary due to the subject property's proximity to Coos Bay. Tidal influences and seasonal changes in precipitation are anticipated to affect the site hydrogeological conditions.

3.0 ESA FINDINGS

3.1 PHASE I ESA FINDINGS

Twenty-four separate Phase I ESAs were completed by URS during the calendar year 2000, and two Phase I ESAs were completed by April 2001 (URS, 2000 and 2001). The properties evaluated included both public and private properties that are developed for commercial or industrial purposes within an area of approximately 15 acres in downtown Coos Bay (the District). Each Phase I ESA report summarized the Phase I ESA methods and findings and identified any recognized environmental conditions (RECs).

On-site or off-site RECs were identified at twenty-two of the twenty-six sites. RECs were primarily related to the long-time use and past disposal practices. As described in the *Draft Work Plan, Phase I Environmental Site Assessments* report (URS, 2000), properties were prioritized for follow-up Phase II assessments based on the RECs identified in the Phase I ESAs. The Phase II priority rankings are summarized in tables included in the *Quality Assurance Project Plan and Sampling and Analysis Plan* (QAPP/SAP; URS, 2002). The priority ranking tables were used as a guide to prioritize the sites that should be addressed first for Phase II ESA activities.

3.2 PHASE II ESA FINDINGS

Eight separate Phase II ESAs were completed during the calendar year 2002. Phase II ESAs were not performed on all twenty-two of the sites with RECs due to owner participation, site eligibility, and other project-specific issues that arose. Phase II ESA field activities took place in June 2002 and included the collection of shallow soil, tidal flat sediment, and shallow groundwater samples variously at eight separate properties. Sample locations are provided on Figure 2. Soil and groundwater analytical data are provided in Tables 1 and 2, respectively.

Eight Phase II ESA reports were submitted to the City of Coos Bay (URS, 2002). Several contaminants of interest were detected in the analyzed samples (see Figures 4a, 4b, and 4c). Additionally, piles of waste metal shavings and slag from machining operations and other solid waste were observed on the Coos Bay tidal flat at three of the properties. To the extent the debris is below the mean high tide mark, it may be situated on land owned by the Oregon Division of State Lands (DSL).

For site screening purposes, analytical data were compared with the USEPA Region 9 Preliminary Remediation Goals for residential and industrial site use. Soil samples analyzed for petroleum hydrocarbons were compared with the DEQ Numeric Soil Cleanup Standards for soil matrix cleanup sites (Oregon Administrative Rule 340-122-0335). The soil matrix cleanup levels are intended for underground storage tank cleanup sites and may not be applicable for the subject property. These federal and state regulatory levels were used for screening purposes only, to provide an indication as to whether the levels of contaminants detected may warrant further investigation.

Soil and groundwater, and tidal flat sediment where present appear to be impacted with primarily metals, petroleum hydrocarbons, and polychlorinated biphenyls (PCBs) at most of the properties assessed. Although the contaminant levels used for screening in the Phase II ESA reports may not be applicable to the individual properties, the presence of these chemicals above the levels identified suggest that site redevelopment may need to address site contamination.

3.3 SUMMARY OF ENVIRONMENTAL ISSUES

Table 3 lists the sites for which Phase II ESAs were conducted. RECs identified during the Phase I ESAs and the findings from the Phase II ESA report are also summarized. Analytical results for the limited Phase II ESA sampling activities identified several contaminants of interest (COI) in sediment, soil, and groundwater. COI include metals, PCBs, petroleum hydrocarbons, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). The COI are discussed below relative to the media they were identified in (sediment, soil, and groundwater). Additionally, solid waste issues are discussed with regard to their potential impacts.

3.3.1 Tidal Flat Sediment

Sediment samples were collected near several of the metal debris piles observed on the Coos Bay tidal flat. Sample locations and concentrations are presented in Figures 4a, 4b, and 4c, and in Tables 1. Analytical results indicate that shallow tidal flat sediments are impacted with low to moderate levels of arsenic, chromium, lead, PCB Aroclor 1254, PCB Aroclor 1260, diesel-range petroleum hydrocarbons, oil-range petroleum hydrocarbons, butyltins, and several SVOCs.

3.3.2 Soil

Surface and subsurface soil samples were collected at several locations within the District. Sample locations and concentrations are presented in Figures 4a, 4b, and 4c, and in Tables 1. Analytical results indicate that soil is impacted at several properties with low to high levels of chromium, lead, PCBs, petroleum hydrocarbons, VOCs, and SVOCs.

Small puddles of oil and distressed vegetation were observed at the Marshfield Corporation scrap yard in areas that were not covered with scrap metal, and along the fence line.

3.3.3 Groundwater

Surface and subsurface soil samples were collected at several locations within the District. Sample locations and concentrations are presented in Figures 4a, 4b, and 4c, and in Tables 1. Analytical results indicate that groundwater is impacted with low to moderate levels of arsenic, one PCB Aroclor, and VOCs.

3.3.4 Solid Waste Accumulations

Solid waste was observed at several locations along the Coos Bay waterfront properties. These areas are described in Phase II ESA reports and summarized below:

- Seven piles of rusted, metallic debris (metal shavings, slag, miscellaneous metallic debris) are located beneath the Koontz Machine & Welding building (Koontz North property). The size of the piles ranges from approximately 7 to 12 feet long, by 5 to 10 feet wide, by 4 to 8 feet tall. The property has been occupied by a machine shop for nearly a century, and a former disposal reportedly practice involved disposing wastes beneath the portion of the shop supported by pilings over the tidal flat.
- Debris, including various rusted metal ship parts, metal slag piles, and plastic battery casings, were observed on the shoreline, on the tidal mudflat, and extending out into the bay along the Coos Bay Towboat and Sweet Trucking properties.
- An approximately 8-foot diameter rusted metal pile is located on the Coos Bay tidal flat of at the rear of the Coos Bay Iron Works shop building. The Coos Bay Iron Works property has been occupied by a machine shop for over a century.

3.3.5 Exempt Areas

As indicated in Figure 3, several properties within the Front Street Heritage District that were not included in Phase I or Phase II ESAs due to owners not participating in the project or for site eligibility criteria (i.e., sites were under petroleum exclusion rules). These properties were either not assessed, or the extent of the assessment was limited to a Phase I ESA (no samples were collect and analyzed).

4.0 SUPPLEMENTAL ACTIVITIES NEEDED

The Phase I and Phase II ESAs conducted for the Brownfield project should be considered a preliminary evaluation of the existing site conditions. The samples collected during the Phase II ESA are considered reconnaissance samples that identify areas of environmental concern. Based on the information collected during these assessments, future investigation should consider the following:

- A more detailed site characterization to assess the nature and the extent of the impacts to sediment, soil, and groundwater.
- Assessment of the current and future land use of the Waterfront Heritage District properties.
- Assessment of the risk posed to human health and ecological receptors from site contamination.
- A feasibility study to quantitatively evaluate the cost and benefit of various potential remedial options.

These recommended actions are discussed below.

4.1 SITE CHARACTERIZATION

Based on the findings of the Phase I and Phase II ESAs, a comprehensive list of data gaps should be identified and a site characterization work plan should be developed to include the following objectives:

- Assess the nature and extent of the impacts to soil, groundwater and sediment.
- Determine the contaminants of interest.
- Estimate the nature and extent of solid waste materials on the tidal flat.

In addition to these three objectives, a site characterization of the District could include a land and water use determination (Section 4.2) and a risk assessment (Section 4.3). The goal of a site characterization is to provide additional information on the nature and extent of site contaminants to aid in the selection of remedial options (Sections 4.4 and 5.0). Site characterization activities that may be necessary for the District could include collection of additional samples (sediment, soil, and groundwater), mapping the extent of contamination, determining the contaminants of concern, mapping the extent of the solid waste, and determining the types of solid waste that were disposed.

As indicated in City of Coos Bay's Quarterly Report No. 8 (October 25, 2001) for the Brownfield Development Pilot Project, the submersed tidelands and filled uplands (the tidal flat) may be regulated by the DSL. The ownership of the tidelands and filled uplands will likely affect the remedial investigation approaches for the debris and impacted tidal sediments.

Additional information on the ownership of these lands should be acquired prior to addressing cleanup options in the conceptual remediation plan.

4.2 LAND AND WATER USE

4.2.1 Front Street Master Plan

The Waterfront Heritage District has historically been a focal point of commerce and industry in the City of Coos Bay since the mid-1800's. Land use associated with the District has included wood products, fishing, machining, and shipping industries. The City of Coos Bay initiated the Front Street Master Plan to facilitate the redevelopment of Front Street for three purposes:

- To provide access to the waterfront so that local citizens will have an understanding of current waterfront activity, as well as the community's historical and cultural connections to the waterfront.
- To provide a vision for increased private investment in the Front Street waterfront area, as use of some of the properties on Front Street has decreased.
- To provide an opportunity for the city and its citizens to diversify the economy of the community by developing a mixed-use area that includes the existing waterfront businesses, new businesses, and public access for the enjoyment of the waterfront.

4.2.2 Land and Water Use Determination Scope of Work

A site specific beneficial land and water use determination for the District should be conducted in accordance with the *Consideration of Land Use in Environmental Remedial Actions* guidance document (DEQ, 1998) and the *Guidance for Conducting Beneficial Water Use Determinations at Environmental Cleanup Sites* (DEQ, 1998). Site characterization data are used to make a land use determination that will aid in assessing risk and in selecting remedial options. A beneficial water use determination consists of two components: 1) development of an understanding of the hydrogeologic setting at the site and, 2) documentation and evaluation of the current and reasonably likely future beneficial water uses within the locality of the facility.

The locality of the facility is defined in Oregon Cleanup Rules as "any point where a human or an ecological receptor contacts, or is reasonably likely to come into contact with, facility-related hazardous substances (OAR 340-122-115[34]). The locality of the facility for a particular environmental medium includes both the current spatial extent of hazardous substances and the projected future extent, if chemicals are expected to migrate. The Front Street Master Plan was developed by the City of Coos Bay to redevelop the Waterfront Heritage District. The plan will not change existing industrial zoning, but will provide additional flexibility to attract potential investors.

As part of the beneficial water use determination, additional information on groundwater use will be obtained. No groundwater or drinking water wells were identified during the Phase I or Phase II ESA work. However, wells may be present near the District.

4.3 RISK ASSESSMENT

A risk assessment evaluates the likelihood of adverse effects occurring in human and ecological receptors potentially exposed to chemicals released in the environment. Risk assessments are not intended to predict the actual risk for an individual. Rather, they estimate risk with an adequate margin of safety, according to the USEPA and DEQ guidelines, for the protection of virtually all receptors that may potentially come into contact with chemicals at a given site.

4.3.1 Screening Level Human Health Risk Assessment

A baseline human health risk assessment (HHRA) consists of four tasks: (1) data evaluation and selection of contaminants of potential concern (COPCs), (2) exposure assessment, including development of a conceptual site model, (3) toxicity assessment, and (4) risk characterization. A screening-level risk assessment does not provide an in-depth assessment of chemical toxicity nor calculate health risks (the second two tasks of the baseline risk assessment process). For the purposes of the Brownfield project, a screening-level risk assessment may be appropriate for the District.

The purpose of a screening-level HHRA is to provide screening-level information on potential human health risks associated with contaminants at the subject property. As indicated previously, analytical data for sediment, soil, and groundwater samples were compared with USEPA and DEQ screening values for screening purposes only. In order to conduct a HHRA, additional information on the nature and extent of the impacts and land and water use would be needed. Based on the information collected during the ESAs, the following risks may be present:

- Impacted sediments and surface soil potentially create a risk to human health by direct exposure or from contaminant partitioning to surface water.
- Impacted subsurface soil potentially creates a risk human health from direct exposure to personnel engaging in activities including trench work, remediation work and landscape activities. Contaminated subsurface soil also potentially presents a health risk to residents and area workers as well through the ingestion and inhalation of contaminated soil particles or vapors.
- Impacted subsurface soil presents a risk to humans engaging in activities including trench work, remediation work and landscape activities through ingestion, dermal contact and inhalation of contaminated soil particles.
- Impacted groundwater may potentially migrate towards Coos Bay. The exposure pathways for humans to contaminants reaching the surface water.

4.3.2 Level I Scoping Ecological Risk Assessment

A Level I Scoping Ecological Risk Assessment (ERA) is a conservative qualitative determination of whether ecological receptors and/or exposure pathways are present or

potentially present at or in the locality of the facility (DEQ, 1998). The following tasks are included in a Level I ERA:

- Determine whether a sensitive environment is present within the locality of the facility. A sensitive environment, as defined in OAR 340-122-0115, is an "area of particular environmental value where a hazardous substance could pose a greater threat than in other non-sensitive areas" (DEQ, 2002). Sensitive environments may include critical habitats, national parks, state parks, wildlife refuges, marine sanctuaries, wilderness areas, and other significant open spaces.
- Conduct a site reconnaissance to assess whether ecologically sensitive species or habitat are present. Ecological features include specific habitats (i.e., terrestrial and aquatic) and their associated wildlife.

Based on the findings of the Level I ERA, additional ecological risk assessment, focusing on the types of receptors identified, may be necessary.

4.4 Feasibility Study

In the context of a hazardous waste site, a feasibility study (FS) has a very specific meaning and requirements. An FS provides an evaluation of alternatives for site remediation. It is designed to be a formal process by which the overall best remedial action is selected, based on criteria including effectiveness, implementability, and cost.

Prior to selecting remedial options through an FS, information about the cleanup site is gathered through a remedial investigation (RI). Information from the RI is used in the FS to develop the general cleanup objectives that are then focused into very specific remediation goals (such as "clean up benzene in the groundwater to less than 5 parts per billion"). From that point, the FS starts out with a very broad range of possible remedial alternatives, and then evaluates them in a very detailed manner against one another.

Generally, though not always, an FS is concluded with the selection of a preferred remedial alternative. The criteria used to evaluate remedial alternatives depends on the regulatory authority overseeing the project. An FS conducted under USEPA oversight has a specific format in which the remedial alternatives are evaluated. For the state of Oregon, the format and evaluation criteria are slightly different.

5.0 CONCEPTUAL REMEDIATION PLAN

Results of Phase I and II ESAs of the study area, real and perceived environmental risks associated with the nature of the contamination were taken into consideration to develop this conceptual remediation plan. Potential remedial options are provided in Appendix A.

5.1 OBJECTIVE

The objective of this plan is to suggest a sequence of interrelated actions for the identified areas of concern. The suggested actions include the following:

- Address data gaps with an additional assessment of the nature and extent of COPCs in soil, groundwater and sediment.
- Evaluate human health and ecological risks associated with identified COPCs and develop site-specific cleanup levels.
- Abatement of the source of the contamination by control and removal.
- Treatment of contaminated sediment and soil to site-specific cleanup levels.
- Treatment of impacted subsurface soil and groundwater to site-specific cleanup levels.
- Develop a monitoring plan to measure the effectiveness of remedial options.

Additional site investigation is necessary to evaluate extent of contamination in tidal flat sediments, surface soil, and the subsurface environment. A HHRA and Level I ERA are necessary to set remediation goals. An abatement action may prevent or reduce the need for future mitigation of contaminants. This may be accomplished by eliminating the source of contamination, removing the metal scrap piles from the tidal flat, and/or physically isolating the contaminants from the at-risk populations. Treatment actions would remove or isolate a sufficient amount of the impacted media to meet cleanup criteria deemed protective of human health and the environment.

5.2 REMEDIAL OPTIONS

The following sections present potential remedial options based on the level of impacts and their associated risk.

5.2.1 Solid Waste and Associated Contamination

Existing aged scrap metal piles along the bay are the primary concern and needs to be addressed properly. Properties that are most affected with these kind of impacts are the Coos Bay Towboat property, the Coos Bay Iron Works property, and the Koontz's North and South properties. Potential remedial options include the following

- No action – No action is taken and the metal piles and solid waste will remain at the sites.

- Containment – Construction of an impermeable containment wall to prevent tidal influences and further disintegration and contaminant migration from metal piles and solid waste into the sediment and aquatic environment. This remedial option could be incorporated into the Front Street Master Plan, and the containment wall could be part of a boardwalk along the bay.
- Source removal and upland disposal – Excavation of the metal piles, collection and removal of solid waste material such as old tires, battery casings and other waste material that currently exists on the tidal flat. The collected material would be placed into an upland containment cell. An upland location for the material would have to be selected for the construction of the temporary containment cell.
- Source removal and off site disposal – Excavation of the metal piles and solid waste, and disposal at an appropriate landfill or a hazardous waste disposal facility.

5.2.2 Sediment and Shallow Soil

The following are potential remedial options for impacted sediment and shallow soil after source removal:

- No action - No action is taken.
- Natural attenuation - COPCs in sediments attenuate through natural processes.
- Capping - Covering contaminated sediments and/or shallow impacted soil with clean material to prevent exposure of human and ecological receptors.
- Dredging and near shore confinement - Removal of contaminated sediment and impacted shallow soil and placement of spoils in a near shore confined aquatic disposal (CAD) facility.
- Dredging and Upland Disposal - Dredging of impacted sediments and placement of spoils in an appropriate upland area or landfill.

5.2.3 Subsurface Soil

Remedial options for subsurface soil are similar to that described for shallow soil and sediment remedies with the following additional in-situ options:

- Solidification/ Stabilization – Use of chemicals to solidify contamination.
- Natural bioattenuation - This remedy is most useful for petroleum-impacted areas.
- Additional remedial options are presented in Appendix A.

5.2.4 Groundwater

Based on the results of the limited investigation conducted during the Phase II ESAs, it appears that groundwater is not impacted with high contaminant concentrations. Therefore, an

institutional control on groundwater use within the Waterfront Heritage District may be warranted.

Institutional controls for groundwater may include restrictions on use for domestic or industrial purposes. The objective of the restriction is to prevent human exposure to contaminated groundwater. This will be achieved by prohibiting the drilling of water supply wells (which do not include environmental monitoring or treatment wells) and prohibiting the use of groundwater as a drinking water source.

Controls on groundwater use may be rescinded or relaxed if groundwater contaminants no longer exceed the site-specific cleanup levels. Groundwater controls may be implemented through a combination of governmental controls (e.g., zoning restrictions or ordinances) and enforceable use restrictions that run with the land (e.g., a servitude or an easement that includes use restrictions).

5.3 EVALUATION CRITERIA FOR REMEDIAL OPTIONS

As mentioned in Section 4.4, remedial options should be evaluated for effectiveness and cost efficiency. Following are general criteria that are commonly considered:

Threshold Criteria - These criteria must be met by the remedial option selected for the site.

- Overall protection of human health and the environment during and after construction (or cleanup).
- Compliance with applicable or relevant and appropriate requirements (ARARs) with federal and state laws and regulations that apply.

Balancing Criteria - These criteria are taken into account during the comparison and selection of preferred options.

- Long-term effectiveness in protecting human health and the environment over time.
- Reduction of toxicity, mobility, or volume by the treatment technologies that may be used.
- Short-term effectiveness in protecting human health and the environment, and how quickly the remedial alternative achieves the protection of human health and the environment.
- Implementability (technical and administrative) associated with carrying out the remedial alternative, including the availability of special materials or services, coordination with regulatory agencies, and potential construction difficulties.
- Cost for the construction, operations, maintenance, and management of the remedial alternative.

Modifying Criteria - These criteria involve the considerations and concerns of the City of Coos Bay and the property owners within the Waterfront Heritage District regarding the potential remedial options selected.

- Federal, State and Tribal acceptance and concerns inherent to people in the vicinity of the District relative to the remedial alternatives.
- Community acceptance pertains to whether the alternative adequately addresses the concerns of the local community.

6.0 SUMMARY

This conceptual remediation plan has been prepared on behalf of the City of Coos Bay as part of the Brownfield Pilot Project for Front Street urban renewal and redevelopment in the Waterfront Heritage District. The Brownfield Development Pilot Project is being conducted as part of the redevelopment and economic revitalization of the Waterfront Heritage District. The purpose of the conceptual remediation plan is to utilize the data collected from assessment activities and identify data gaps, possible environmental threats, and suggest a roadmap to the management of impacted areas. This document provides planning-level alternatives for the cleanup of impacted media identified in the Phase II ESAs.

Twenty-four separate Phase I ESAs and eight Phase II ESAs were completed. The properties evaluated included both public and private properties that are developed for commercial or industrial purposes within downtown Coos Bay. Each Phase I ESA report identified any recognized environmental conditions (RECs) at a property. Phase II ESAs were not conducted on all properties with RECs due to owner participation, site eligibility, and other project-specific issues that arose. Analytical results for the limited Phase II ESA sampling activities identified several contaminants of interest in sediment, soil, and groundwater. Additionally, solid waste was observed on the tidal flat along Coos Bay.

Considering the data collected during these assessments, the City of Coos Bay should consider the following prior to selecting a remedial option:

- Conduct a site characterization to assess the nature and the extent of the impacts to sediment, soil, and groundwater.
- Assess the current and future land use of the Waterfront Heritage District.
- Assess the risk posed to human health and ecological receptors from the solid waste or impacted materials.
- Based on the information collected during a site characterization or remedial investigation, conduct a feasibility study prior the selection of remedial options.

Potential remedial options include the following:

- Abatement of the source of the contamination by control and removal. This could include the construction of an impermeable containment wall or the excavation of the metal piles and impacted sediments or soil.
- Treatment of contaminated sediment and soil to site-specific cleanup levels. This could include natural attenuation, dredging, or capping.
- Treatment of impacted subsurface soil and groundwater to site-specific cleanup levels. This could include natural attenuation, solidification/stabilization, institutional controls, or the installation of treatment systems.

- Develop a monitoring plan to measure the effectiveness of natural attenuation on the contaminants.

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TABLE 1
SOIL AND SEDIMENT ANALYTICAL SUMMARY
City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

Property Name	Reference Levels	Marshfield Corporation				Marshfield Bargain House	Koontz North				Koontz South		
Map ID	Region 9 PRGs Industrial(1)	MC01	MC02	MC03	MC04	BH01	KN01	KN02	KN03	KN04	KS01	KS02	KS03
Sample ID		GP-MC01-SS	GP02-MC04-SS	GP03-MC07-SS	GP04-MC10-SS	GP01-BH01-SS	GS-KN01-SS	GS-KN02-SS	GS-KN03-SS	GS-KN04-SS	GP01-KS01-SS	GP02-KS03-SS	GP03-KS05-SS
Sample Depth (ft bgs)		0 - 2	0 - 2	0 - 2.5	0 - 2	2 - 4	0.5	1.5	0.5	1.5	6 - 8	6.5 - 7.5	7.5 - 8.5
Polychlorinated Biphenyls - EPA Method 8082 (mg/kg)													
Aroclors 1016, 1221, 1232, 1242, and 1248	1.00	R	R	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	1.00	3.8	24.8	0.0865	49.1	0.186	0.00527	0.00826	ND	ND	ND	ND	0.00818
Aroclor 1260	1.00	0.209	4.51	ND	ND	0.397	ND	ND	ND	ND	ND	ND	ND
RCRA 8 METALS - EPA Method 6010/6020 (mg/kg)													
Arsenic (As)	2.7	6.15	5.45	3.9	17.2	13.9	15.7	11.5	25.9	11.8	5.32	3.45	2.98
Barium (Ba)	100000	115	200	18.5	390	275	71	55.1	70.3	54.9	48	16.1	9.55
Cadmium (Cd)	810	3.74	6.53	ND	25.2	16.3	13	0.822	ND	ND	ND	ND	ND
Chromium (Cr)	64	41.1	28.4	11.8	78.5	29.8	82.2	95.2	272	120	30.7	12.7	7.75
Lead (Pb)	750	4090	1330	33.6	7310	29700	347	79.6	429	150	62.6	4.21	4.83
Mercury (Hg)	610	0.618	1.81	ND	0.178	0.264	0.521	0.201	1.57	0.223	0.127	ND	ND
Selenium (Se)	10000	ND	ND	ND	0.944	0.821	ND	ND	ND	ND	ND	ND	ND
Silver (Ag)	10000	0.536	ND	ND	1.56	1.26	0.943	ND	0.846	ND	ND	ND	ND
Petroleum Hydrocarbons (Various Methods, mg/kg)													
NWTPH-HCID ⁽⁵⁾													
Gasoline	NR	>22.3	>21	<23.5	>23.1	>22.5	<41.3	<36.1	<27.5	<43.4	>25.5	<29.1	<25.3
Diesel	NR	>55.7	>52.6	<58.7	>57.7	>56.2	<103	<90.2	>68.7	<109	>63.8	>72.7	<63.3
Motor Oil	NR	>111	>105	<117	>115	>112	<206	<180	>137	<217	>128	<145	>127
Gasoline (NWTPH-Gx) ⁽⁶⁾	NR	18.9	13.3	NA	15.1	16.1	NA	NA	NA	NA	3.66	NA	NA
#2 Diesel (NWTPH-Dx) ⁽⁷⁾	NR	705	5020	NA	5100	1520	NA	NA	127	NA	343	810	102
Motor Oil (NWTPH-Dx) ⁽⁷⁾	NR	1780	20400	NA	17600	7410	NA	NA	264	NA	1420	205	192
Tributyltins - Krone GC/MS ⁽⁴⁾ (µg/kg)													
Dibutyltin	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Monobutyltin	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrabutyltin	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tributyltin	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SVOCs - EPA Method 8270 (µg/kg)													
2-Chloronaphthalene	27000000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	38000000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	100000000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (a) anthracene	2900	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (a) pyrene	290	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)fluoranthenes	2100/21000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (ghi) perylene	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	290000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo (a,h) anthracene	290	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	37000000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	330000000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno (1,2,3-cd) pyrene	2900	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	190000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	54000000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA = Not Analyzed

NR = Not Regulated or benchmark not developed

ND = Not Detected

R - Sample Rejected

mg/kg = milligrams per kilogram

µg/kg = micrograms per kilogram

ft bgs = feet below ground surface

Bold values indicate detections

Highlighted cells indicate the reported concentration is above the corresponding regulatory reference level

⁽¹⁾ = EPA Region 9 Preliminary Remediation Goals (PRGs) for Industrial Soil

⁽⁴⁾ = Method based on Puget Sound Estuary Protocols

⁽⁵⁾ = Northwest Total Petroleum Hydrocarbon (NWTPH)-Hydrocarbon Identification (HCID) method

⁽⁶⁾ = NWTPH-Gasoline (Gx) method (gasoline-range hydrocarbons)

⁽⁷⁾ = NWTPH-Diesel (Dx) method (diesel- and heavy oil-range hydrocarbons)

TABLE 1
SOIL AND SEDIMENT ANALYTICAL SUMMARY
City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

Property Name	Reference Levels	Coos Bay Iron Works			Coos Bay Towboat			Sweet Trucking		Goergen Property
Map ID	Region 9 PRGs Industrial(1)	IW01	IW02	IW03	TB01	TB02	TB03	ST01	ST02	GP01
Sample ID		GS-CBIW01-SS	GS-CBIW02-SS	GS-CBIW04-SS	GP01-TB01-SS	GP02-TB02-SS	GS-TB06-SS	GP01-ST01-SS	GP02-ST03-SS	GP01-GP01-SS
Sample Depth (ft bgs)		0.5 - 1.0	0.5 - 1.0	0.3 - 0.5	6.5 - 7.5	5.5 - 6.5	1.0	10.5 - 12	6.5 - 7.5	6 - 7
Polychlorinated Biphenyls - EPA Method 8082 (mg/kg)										
Aroclors 1016, 1221, 1232, 1242, and 1248	1.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	1.00	0.184	0.0217	0.0906	ND	ND	ND	ND	ND	ND
Aroclor 1260	1.00	ND	0.0104	0.0715	ND	ND	ND	ND	ND	ND
RCRA 8 METALS - EPA Method 6010/6020 (mg/kg)										
Arsenic (As)	2.7	47.2	7.77	182	15	8.39	13.1	11.5	4.16	2.53
Barium (Ba)	100000	145	26.2	150	37.6	23.9	35.3	122	212	11.4
Cadmium (Cd)	810	13.4	ND	ND	0.983	ND	10.3	ND	ND	ND
Chromium (Cr)	64	621	31.1	354	47	20.3	41.6	56.9	48	7.8
Lead (Pb)	750	7120	140	53400	26.6	10.2	1250	44.1	10.8	2.28
Mercury (Hg)	610	0.499	0.168	7.55	0.0637	0.0257	0.245	0.1	0.0719	ND
Selenium (Se)	10000	ND	2.89	1.56	1	ND	ND	1.18	ND	ND
Silver (Ag)	10000	4.03	0.629	24.8	ND	ND	ND	ND	ND	ND
Petroleum Hydrocarbons (Various Methods, mg/kg)										
NWTPH-HCID ⁽⁵⁾										
Gasoline	NR	<25.3	<19.9	<31.3	<28.3	>25.6	<33	<29.7	<28.3	<24.3
Diesel	NR	>63.3	<49.7	>78.3	<70.8	>63.9	>82.4	<74.4	<70.7	<60.6
Motor Oil	NR	>127	>99.5	>157	<142	>128	>165	>149	<141	<121
Gasoline (NWTPH-Gx) ⁽⁶⁾	NR	NA	NA	NA	NA	7.59	NA	NA	NA	NA
#2 Diesel (NWTPH-Dx) ⁽⁷⁾	NR	103	34.2	319	NA	2510	109	32.8	NA	NA
Motor Oil (NWTPH-Dx) ⁽⁷⁾	NR	726	304	657	NA	17700	482	213	NA	NA
Tributyltins - Krone GC/MS ⁽⁴⁾ (µg/kg)										
Dibutyltin	NR	24.1	ND	114	NA	NA	NA	NA	NA	NA
Monobutyltin	NR	17.7	ND	12.5	NA	NA	NA	NA	NA	NA
Tetrabutyltin	NR	ND	ND	ND	NA	NA	NA	NA	NA	NA
Tributyltin	NR	54.1	ND	288	NA	NA	NA	NA	NA	NA
SVOCs - EPA Method 8270 (µg/kg)										
2-Chloronaphthalene	27000000	ND	ND	ND	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NR	137	16.2	ND	NA	NA	NA	NA	NA	NA
Acenaphthene	38000000	111	ND	57.5	NA	NA	NA	NA	NA	NA
Acenaphthylene	NR	280	49.7	56.8	NA	NA	NA	NA	NA	NA
Anthracene	100000000	361	31.5	155	NA	NA	NA	NA	NA	NA
Benzo (a) anthracene	2900	495	97.3	415	NA	NA	NA	NA	NA	NA
Benzo (a) pyrene	290	485	122	411	NA	NA	NA	NA	NA	NA
Benzo(a)fluoranthenes	2100/21000	945	177	796	NA	NA	NA	NA	NA	NA
Benzo (ghi) perylene	NR	510	115	238	NA	NA	NA	NA	NA	NA
Chrysene	290000	543	102	495	NA	NA	NA	NA	NA	NA
Dibenzo (a,h) anthracene	290	ND	ND	29.9	NA	NA	NA	NA	NA	NA
Fluoranthene	37000000	1090	215	1750	NA	NA	NA	NA	NA	NA
Fluorene	33000000	131	10.7	71.3	NA	NA	NA	NA	NA	NA
Indeno (1,2,3-cd) pyrene	2900	470	89.1	289	NA	NA	NA	NA	NA	NA
Naphthalene	190000	225	45.9	43.4	NA	NA	NA	NA	NA	NA
Phenanthrene	NR	543	100	570	NA	NA	NA	NA	NA	NA
Pyrene	54000000	1080	205	1240	NA	NA	NA	NA	NA	NA

Notes:

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R = Sample Rejected

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Bold values indicate detections

Highlighted cells indicate the reported concentration is above the corresponding regulatory

⁽¹⁾ = EPA Region 9 Preliminary Remediation Goals (PRGs) for Industrial Soil

⁽⁴⁾ = Method based on Puget Sound Estuary Protocols

⁽⁵⁾ = Northwest Total Petroleum Hydrocarbon (NWTPH)-Hydrocarbon Identification (HCID) n

⁽⁶⁾ = NWTPH-Gasoline (Gx) method (gasoline-range hydrocarbons)

⁽⁷⁾ = NWTPH-Diesel (Dx) method (diesel- and heavy oil-range hydrocarbons)

TABLE 2
GROUNDWATER ANALYTICAL SUMMARY
City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

Property Name	Reference Levels Region 9 PRGs Tap Water ⁽¹⁾	Marshfield Corporation				Marshfield Bargain House	Koontz South			Coos Bay Towboat		Sweet Trucking		Goergen Property
Sample ID		MC01	MC02	MC03	MC04	BH01 ⁽²⁾	KS01	KS02	KS03	TB02	TB01	ST01	ST02	GP01
Location		GP-MC03-GW	GP02-MC06-GW	GP03-MC09-GW	GP04-MC12-GW	GP01-BH01-GW	GP01-KS02-GW	GP02-KS04-GW	GP03-KS06-GW	GP02-TB03-GW	GP01-TB04-GW	GP01-ST02-GW	GP02-ST05-GW	GP01-GP02-GW
Screen Interval (ft bgs)		7 - 11	7 - 11	4 - 8	4 - 8	4-8	8 - 12	7 - 11	8 - 12	20 - 24	8 - 12	8 - 12	7 - 11	4 - 8
Polychlorinated Biphenyls - EPA Method 8082 (mg/L)														
Aroclor 1016	0.9605	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1221	0.0336	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1232	0.0336	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1242	0.0336	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1248	0.0336	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	0.0336	ND	0.0474	0.0663	0.177	ND	ND	ND	0.0387	ND	ND	ND	ND	ND
Aroclor 1260	0.0336	ND	ND	ND	ND	ND	ND	ND	ND	0.0204	ND	ND	ND	ND
RCRA 8 METALS - EPA Method 6010/6020 (mg/L)														
Arsenic (As)	0.000045	ND	ND	ND	ND	ND	0.0201	0.00642	0.0326	ND	0.0153	0.0135	0.00566	ND
Barium (Ba)	2.6	ND	ND	ND	ND	ND	0.797	ND	0.273	ND	0.178	0.461	0.0935	ND
Cadmium (Cd)	0.018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium (Cr)	0.11	ND	ND	ND	ND	ND	ND	0.0377	ND	ND	0.0353	ND	ND	ND
Lead (Pb)	NR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg)	0.011	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium (Se)	0.18	ND	ND	ND	ND	ND	0.0546	0.0151	0.106	ND	0.0326	0.0269	0.00918	ND
Silver (Ag)	0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VOCs - EPA Method 8260 (µg/l)														
1,1-Dichloroethane	810	ND	ND	0.545	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.12	ND	ND	ND	ND	4.2	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	610	ND	ND	ND	ND	2.54	3.08	ND	2.87	ND	ND	3.62	ND	ND
Carbon disulfide	1000	ND	ND	ND	ND	ND	ND	ND	0.551	0.568	ND	ND	ND	ND
Bromodichloromethane	0.18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.17
Chloroform	0.16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.61
All Other VOCs	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
NA = Not Analyzed
NR = Not Regulated
*- = Not Applicable
ND = Not Detected
mg/L = milligrams per liter
µg/L = micrograms per liter
Bold values indicate detections
Highlighted cells indicate the reported concentration is above the corresponding regulatory reference level
⁽¹⁾ = EPA Region 9 Preliminary Remediation Goals (PRGs) for Tap Water
⁽²⁾ = Maximum value of Sample Location GP01-BH01-GW and the field duplicate GP01-BH02-GW.

TABLE 3
SITE ASSESSMENT SUMMARY
City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

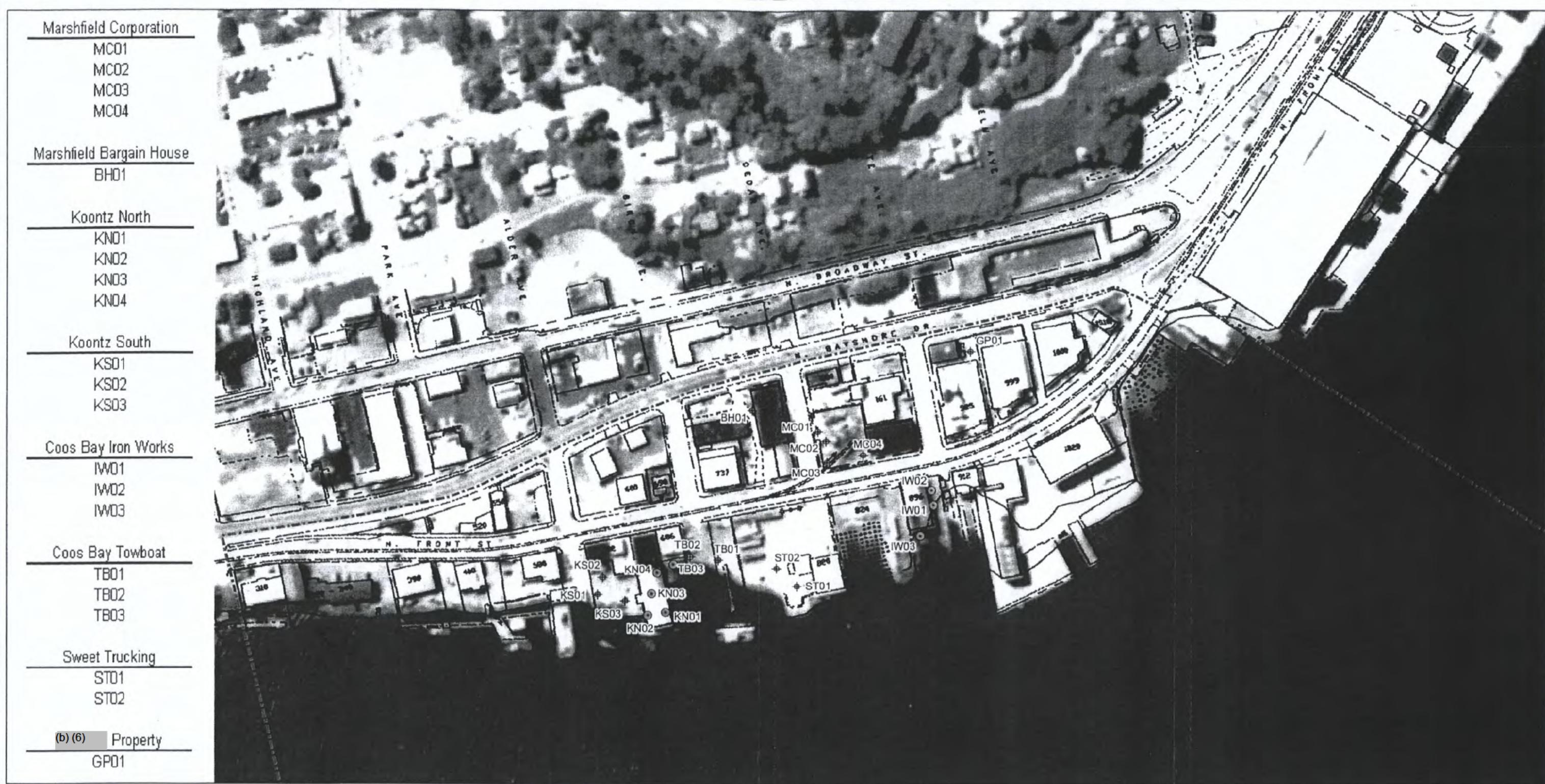
Site ID	Property Name	Address	Current Use	Phase I ESA Recognized Environmental Conditions	Phase II ESA Findings
23 TL3100	Marshfield Corp.	891 N. Front Street	Scrapyard	<u>On Site:</u> Metal recycling operations conducted on site currently and historically may have created subsurface contamination. <u>Off Site:</u> None	<u>Soil:</u> Impacted with moderate to high levels of chromium, lead, polychlorinated biphenyls (PCBs), and petroleum hydrocarbons. Impacted with low to moderate levels of two volatile organic compounds (VOCs). <u>Groundwater:</u> Impacted with low to moderate levels of one PCB Aroclor and one VOC.
7 TL700	Koontz Machine & Welding, Inc. North	680 N. Front Street	Machine shop	<u>On Site:</u> Evidence of past on-site disposal of metal shavings from machining work and metal parts and debris was indicated through interviews and observation. The wastes were disposed of beneath the shop on the tidal flat or in Coos Bay. Rust staining observed on asphalt pavement adjacent to dumpsters used to store metal shavings on adjoining Koontz property to the south. <u>Off Site:</u> None	<u>Tidal Flat Sediments:</u> Impacted with low to moderate levels of arsenic, chromium, lead, one PCB Aroclor, diesel-range hydrocarbons, and oil-range hydrocarbons. <u>Groundwater:</u> No samples collected. <u>Other:</u> Approximately 3,400 cubic feet (126 cubic yards) of metal debris observed in seven piles beneath the shop on the tidal flat.
6 TL800	Koontz Machine & Welding, Inc. South	600 N. Front Street	Machine shop	<u>On Site:</u> Potential soil and groundwater contamination. The property has been occupied by a machine shop for approximately 30 years. Rust staining observed on asphalt pavement adjacent to dumpsters used to store metal shavings. Surface water at this location likely flows to the north beneath the adjoining Koontz building and into Coos Bay. <u>Off-Site:</u> None	<u>Soil:</u> Impacted with low to moderate levels of arsenic, chromium, one PCB Aroclor, diesel-range hydrocarbons, and oil-range hydrocarbons. <u>Groundwater:</u> Impacted with low levels of arsenic.

TABLE 3
SITE ASSESSMENT SUMMARY
City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

Site ID	Property Name	Address	Current Use	Phase I ESA Recognized Environmental Conditions	Phase II ESA Findings
8 / 9 TL600 TL500	Coos Bay Towboat Co. Office / Parking Lot	686 N. Front Street / 690 N. Front Street	Office and warehouse	<p><u>On Site:</u> The office property has been occupied by a machine shop, steel fabricating facility, or other industrial operation for approximately 50 years. Motor or lubricating oils or other petroleum products have probably been used on site. Potential metals contamination to soil at the office and parking lot properties exists from apparent on site disposal of various rusted metallic items, metal slag, and plastic battery casings located on tidal flat and along the shoreline.</p> <p><u>Off Site:</u> Adjoining leaking underground storage tank (LUST) Site – New Horizon Trading Company.</p>	<p><u>Soil/Tidal Flat Sediments:</u> Impacted with moderate to high levels of lead, diesel-range hydrocarbons, and oil-range hydrocarbons. Impacted with low to moderate levels of arsenic, chromium, and gasoline-range hydrocarbons.</p> <p><u>Groundwater:</u> Impacted with low levels of arsenic.</p> <p><u>Other:</u> A metal slag pile extends from the property onto the tidal flat.</p>
11 TL100	Coos Bay Iron Works	896 N. Front Street	Machine shop	<p><u>On Site:</u> The subject property has been occupied by a machine shop for over a century. Metal shavings from machining work and metal parts and debris were observed on the tidal flat at the rear of the shop building.</p> <p><u>Off Site:</u> Contaminated sandblast grit on subject property from adjoining Hillstrom's Shipyard site.</p>	<p><u>Soil/Tidal Flat Sediments:</u> Impacted with moderate to high levels of arsenic, chromium, lead, and two semivolatile organic compounds (SVOCs). Impacted with low to moderate levels of PCBs, diesel-range hydrocarbons, oil-range hydrocarbons, butyltins, and several SVOCs.</p> <p><u>Groundwater:</u> No samples collected.</p> <p><u>Other:</u> A metal slag pile extends from the property onto the tidal flat.</p>
10 TL200	Sweet Trucking Co.	820 N. Front Street	Truck maintenance & storage	<p><u>On Site:</u> Petroleum staining observed on concrete flooring. Various drums and containers observed in the shop building.</p> <p>Various rusted metallic items, metal slag piles, and plastic battery casings were observed on a rocky shelf beneath the property.</p> <p><u>Off Site:</u> Adjoining LUST Site – New Horizon Trading Company.</p>	<p><u>Soil:</u> Impacted with low levels of arsenic, chromium, and oil-range hydrocarbons.</p> <p><u>Groundwater:</u> Impacted with low levels of arsenic.</p>

TABLE 3
SITE ASSESSMENT SUMMARY
City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

Site ID	Property Name	Address	Current Use	Phase I ESA Recognized Environmental Conditions	Phase II ESA Findings
20 TL2800	Marshfield Bargain House	790 N. Bayshore Drive	Workyard	<u>On Site:</u> Stained soil near drums of waste oil. <u>Off Site:</u> A scrapyard adjoins the property to the east. Adjoining LUST site – New Horizon Trading Company.	<u>Soil:</u> Impacted with high levels of lead. Impacted with moderate levels of diesel- and oil-range hydrocarbons. Impacted with low to moderate levels of arsenic, PCBs, gasoline-range hydrocarbons, and naphthalene. <u>Groundwater:</u> Impacted with low to moderate levels of 1,2-dichloroethane and acetone.
26 TL500	(b) (6)	925 N. Front Street	Cold storage and ice making	<u>On Site:</u> A drywell was observed on the subject property. Drains located in an ice production room and near on site condenser units reportedly drain excess water to the dry well. No spills of freon or other hazardous substances to the drain system or dry wells are known to have occurred. However, dry wells are recognized as a common source of subsurface contamination. <u>Off Site:</u> None	<u>Soil:</u> Impacted with low levels of arsenic. <u>Groundwater:</u> Impacted with low levels of two VOCs.



- Marshfield Corporation
 - MC01
 - MC02
 - MC03
 - MC04
- Marshfield Bargain House
 - BH01
- Koontz North
 - KND1
 - KND2
 - KND3
 - KND4
- Koontz South
 - KS01
 - KS02
 - KS03
- Coos Bay Iron Works
 - IW01
 - IW02
 - IW03
- Coos Bay Towboat
 - TB01
 - TB02
 - TB03
- Sweet Trucking
 - ST01
 - ST02
- (b) (6) Property
 - GP01



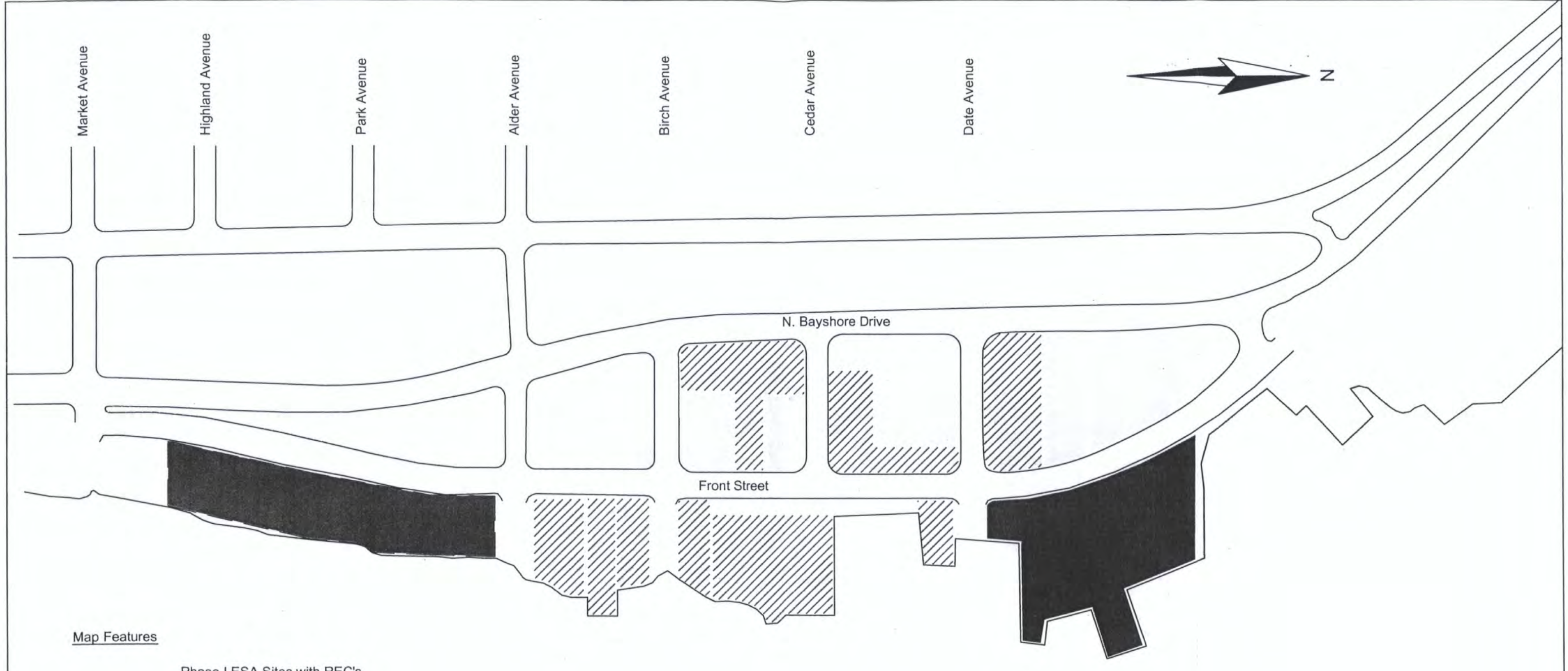
- Map Features:**
- Pilot Boundary
 - Soil and Groundwater Sample Locations
 - Soil/Sediment Sample Location

**SITE BOUNDARY AND
SAMPLE LOCATION MAP**
Soil, Sediment, & Groundwater

City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon



FIGURE 2



Map Features

- Phase I ESA Sites with REC's
- Phase I ESA Site with no REC's
- Phase I & II ESA Sites
- Exempt Sites

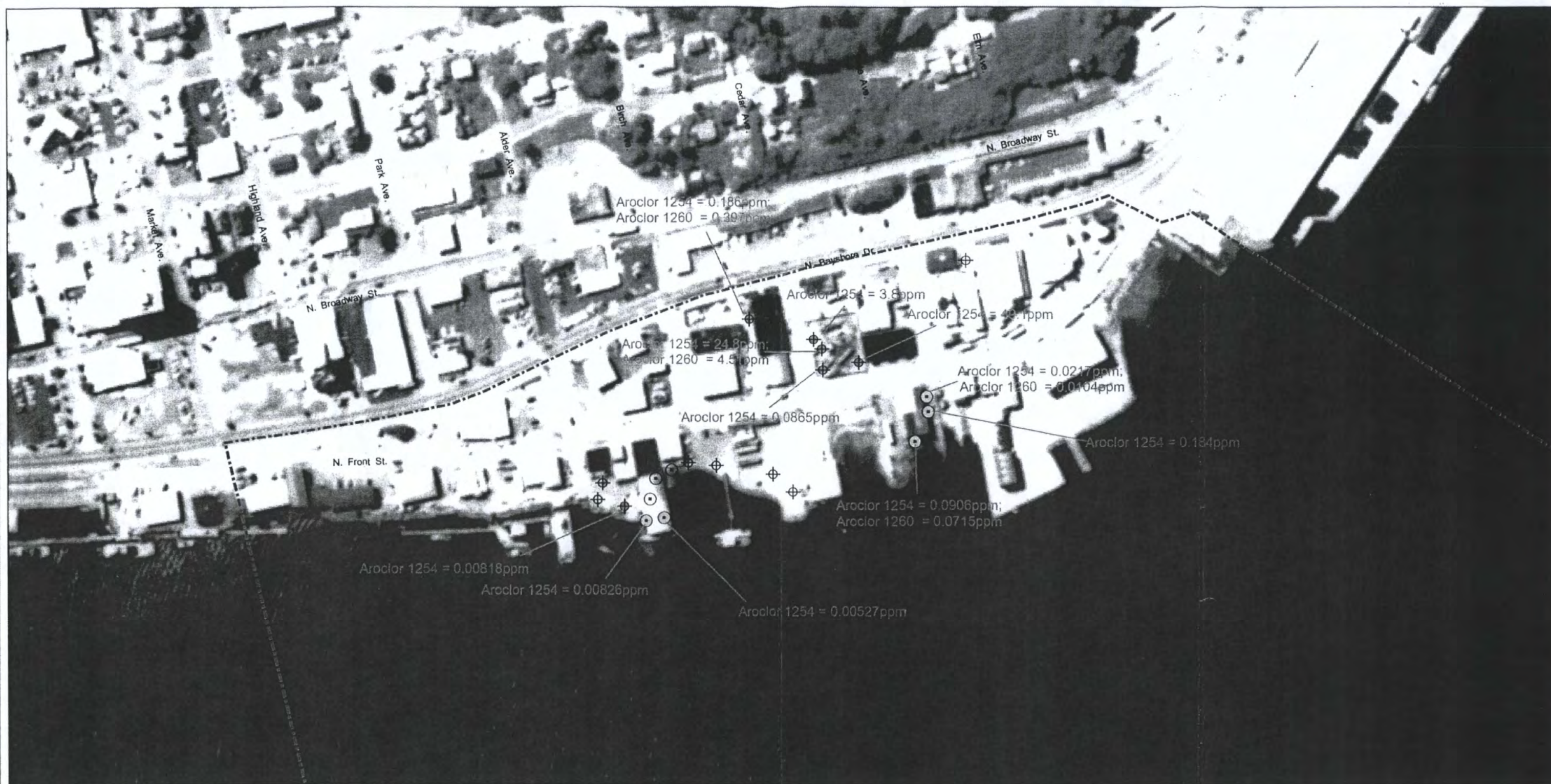


PROPERTY DELINATION MAP

City of Coos Bay
 Waterfront Heritage District
 Coos Bay, Oregon

April 2003
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FIGURE 3



URS

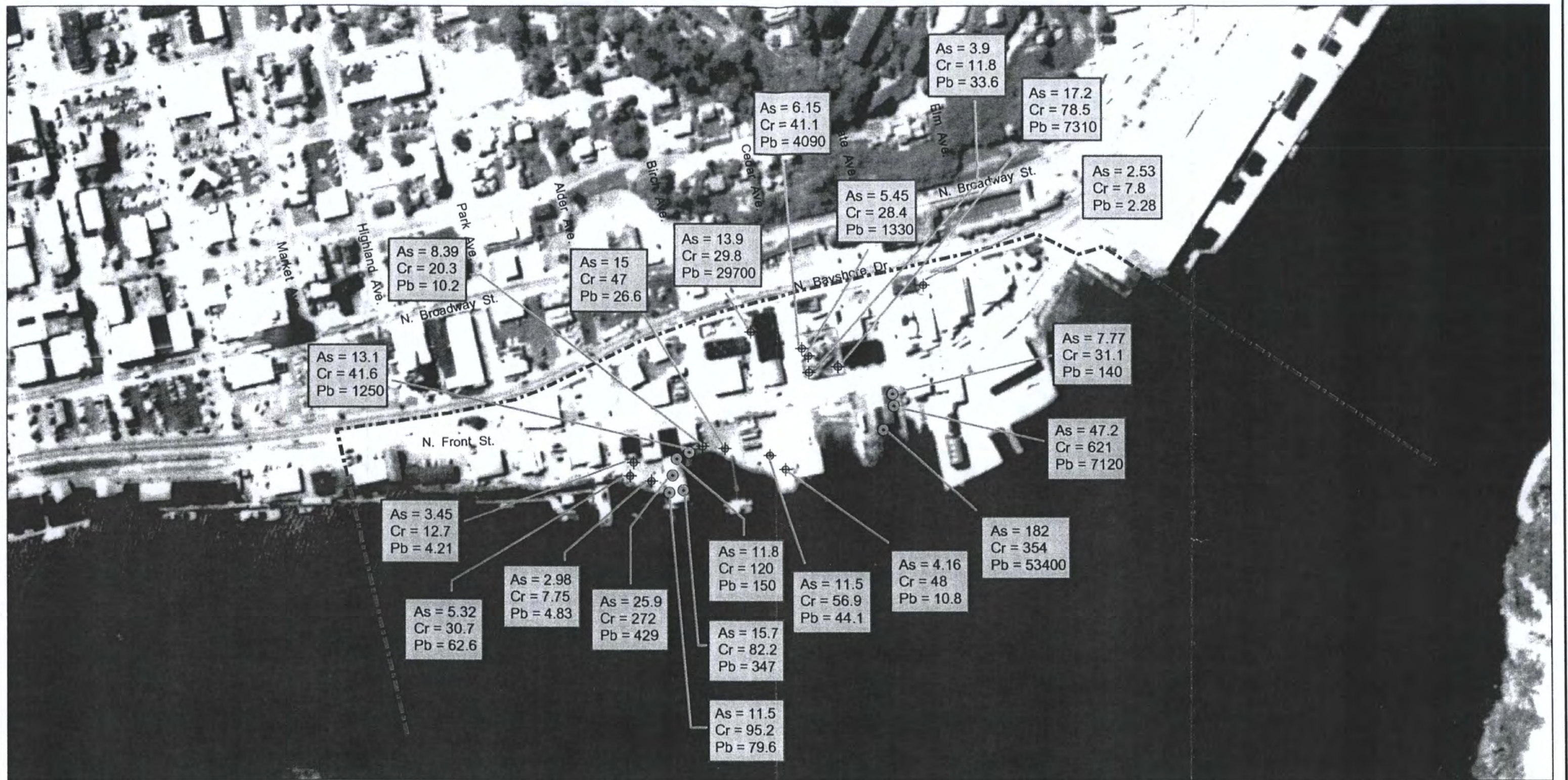
Map Features:

- ⊕ Soil Sample (PCB Aroclor Detection & Concentration in ppm)
- ⊕ Soil Sample (PCB Not Detected)
- ⊙ Soil/Sediment Sample (PCB Aroclor Detection & Concentration in ppm)
- ⊙ Soil/Sediment Sample (PCB Not Detected)
- - - Pilot Boundary

SOIL PCB AROCLOR DETECTIONS

City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

FIGURE 4a



Map Features:

- ⊕ Soil Sample Locations
- ⊙ Soil/Sediment Sample Location
- - - Pilot Boundary

Arsenic (As) = ppm
Chromium (Cr) = ppm
Lead (pb) = ppm

**SOIL ARSENIC, CHROMIUM, AND
LEAD DETECTIONS**

City of Coos Bay
Waterfront Heritage District
Coos Bay, Oregon

URS

FIGURE 4b

Three primary strategies used separately or in conjunction to remediate most sites are:

- Destruction or alteration of contaminants.
- Extraction or separation of contaminants from environmental media.
- Immobilization of contaminants.

Treatment technologies capable of contaminant destruction by altering their chemical structure are thermal, biological, and chemical treatment methods. These destruction technologies can be applied in situ or ex situ to contaminated media.

Treatment technologies commonly used for extraction and separation of contaminants from environmental media include soil treatment by thermal desorption, soil washing, solvent extraction, and soil vapor extraction (SVE) and ground water treatment by either phase separation, carbon adsorption, air stripping, ion exchange, or some combination of these technologies. Selection and integration of technologies should use the most effective contaminant transport mechanisms to arrive at the most effective treatment scheme. For example, more air than water can be moved through soil. Therefore, for a volatile contaminant in soil that is relatively insoluble in water, SVE would be a more efficient separation technology than soil flushing or washing.

Immobilization technologies include stabilization, solidification, and containment technologies, such as placement in a secure landfill or construction of slurry walls. No immobilization technology is permanently effective, so some type of maintenance is desired. Stabilization technologies are often proposed for remediating sites contaminated by metals or other inorganic species

TREATMENT OF METALS IN SOIL AND SEDIMENT

In Situ Physical/Chemical Treatment

The main advantage of in situ treatment is that it allows soil to be treated without being excavated and transported, resulting in potentially significant cost savings. However, in situ treatment generally requires longer time periods, and there is less certainty about the uniformity of treatment because of the variability in soil and aquifer characteristics and because the efficacy of the process is more difficult to verify.

Physical/chemical treatment uses the physical properties of the contaminants or the contaminated medium to destroy (i.e., chemically convert), separate, or contain the contamination. Soil vapor extraction uses the contaminant's volatility to separate it from the soil. Soil flushing uses the contaminant's solubility in liquid to physically separate it from the soil. Surfactants may be added to the flushing solution to chemically increase the solubility of a contaminant. Solidification/stabilization also uses both physical and chemical means. Solidification encapsulates the contaminant, while stabilization physically alters or binds with the contaminant. Pneumatic fracturing is an enhanced technique that physically alters the contaminated media's permeability by injecting pressurized air to develop cracks in consolidated materials.

Physical/chemical treatment is typically cost effective and can be completed in short time periods (in comparison with biological treatment). Equipment is readily available and is not engineering or energy-intensive. Treatment residuals from separation techniques will require treatment or disposal, which will add to the total project costs and may require permits. Extraction fluids from soil flushing will increase the mobility of the contaminants, so provisions must be made for subsurface recovery.

In Situ Solidification/ Stabilization

Solidification/stabilization (S/S) reduces the mobility of hazardous substances and contaminants in the environment through both physical and chemical means. Unlike other remedial technologies, S/S seeks to trap or immobilize contaminants within their "host" medium (i.e., the soil, sand, and/or building materials that contain them) instead of removing them through chemical or physical treatment. Leachability testing is typically performed to measure the immobilization of contaminants. S/S techniques can be used alone or combined with other treatment and disposal methods to yield a product or material suitable for land disposal or, in other cases, that can be applied to beneficial use. These techniques have been used as both final and interim remedial measures.

Applicability:

The target contaminant group for in situ S/S is generally inorganics (including radionuclides).

Limitations:

Factors that may limit the applicability and effectiveness of the in situ S/S include:

- Depth of contaminants may limit some types of application processes.
- Future usage of the site may "weather" the materials and affect ability to maintain immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with variations of this process. Treatability studies are generally required.
- Reagent delivery and effective mixing are more difficult than for ex situ applications.
- Like all in situ treatments, confirmatory sampling can be more difficult than for ex situ treatments.
- The solidified material may hinder future site use.
- Processing of contamination below the water table may require dewatering.

Cost:

Costs for Auger/Caisson and Reagent/Injector Head Systems processes vary widely according to materials or reagents used, their availability, project size, and chemical nature of contaminants (e.g., types and concentration levels for shallow applications). The in situ soil mixing/auger techniques average \$50 to \$80 per cubic meter (\$40 to \$60 per cubic yard) for the shallow applications and \$190 to \$330 per cubic meter (\$150 to \$250 per cubic yard) for the deeper applications.

The shallow soil mixing technique processes 36 to 72 metric tons (40 to 80 tons) per hour on average, and the deep soil mixing technique averages 18 to 45 metric tons (20 to 50 tons) per hour.

The major factor driving the selection process beyond basic waste compatibility is the availability of suitable reagents. Auger/Caisson and Reagent/Injector Head Systems processes require that potentially large volumes of bulk reagents and additives be transported to project sites. Transportation costs can dominate project economics and can quickly become uneconomical in cases where local or regional material sources are unavailable.

The cost for grout injection varies depending on site-specific conditions. Costs for drilling can range from \$50 to \$150/ft and grouting from \$50 to \$75/ft, not including mobilization, wash disposal, or adverse site condition expenses.

Ex Situ Physical/Chemical Treatment for Soil, Sediment, Bedrock and Sludge

The main advantage of ex situ treatment is that it generally requires shorter time periods than in situ treatment, and there is more certainty about the uniformity of treatment because of the ability to homogenize, screen, and continuously mix the soil. Ex situ treatment, however, requires excavation of soils, leading to increased costs and engineering for equipment, possible permitting, and material handling/worker exposure conditions.

Physical/chemical treatment uses the physical properties of the contaminants or the contaminated medium to destroy (i.e., chemically convert), separate, or immobilize the contamination. Chemical reduction/oxidation and dehalogenation (APEG, BCD or glycolate) are destruction technologies. Soil washing, SVE, and solvent extraction are separation techniques, and Solidification/Stabilization (S/S) is an immobilization technique.

Physical/chemical treatment is typically cost effective and can be completed in short time periods (in comparison with biological treatment). Equipment is readily available and is not engineering or energy-intensive. Treatment residuals from separation techniques will require treatment or disposal, which will add to the total project costs and may require permits.

Solidification/Stabilization

Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their

mobility (stabilization). Ex situ S/S, however, typically requires disposal of the resultant materials. Under CERCLA, material can be replaced on site.

There are many innovations in the stabilization and solidification technology. Most of the innovations are modifications of proven processes and are directed to encapsulation or immobilizing the harmful constituents and involve processing of the waste or contaminated soil. Nine distinct innovative processes or groups of processes include: (1) bituminization, (2) emulsified asphalt, (3) modified sulfur cement, (4) polyethylene extrusion, (5) pozzolan/Portland cement, (6) radioactive waste solidification, (7) sludge stabilization, (8) soluble phosphates, and (9) vitrification/molten glass.

Applicability:

The target contaminant group for ex situ S/S is inorganics, including metals. Most S/S technologies have limited effectiveness against organics and pesticides, except vitrification which destroys most organic contaminants

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Environmental conditions may affect the long-term immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with different processes. Treatability studies are generally required.
- Organics are generally not immobilized.
- Long-term effectiveness has not been demonstrated for many contaminant/process combinations.

Cost:

Ex situ solidification/stabilization processes are among the most mature remediation technologies. Representative overall costs from more than a dozen vendors indicate an approximate cost of under \$110 per metric ton (\$100 per ton), including excavation.

Chemical Reduction/Oxidation

Reduction/oxidation (Redox) reactions chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, and/or inert. Redox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons). The oxidizing agents most commonly used for treatment of hazardous contaminants are ozone, hydrogen peroxide,

hypochlorites, chlorine, and chlorine dioxide. Chemical reduction/oxidation is a short- to medium-term technology.

Applicability:

The target contaminant group for chemical redox is inorganics. The technology can be used but may be less effective against nonhalogenated VOCs and SVOCs, fuel hydrocarbons, and pesticides.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Incomplete oxidation or formation of intermediate contaminants may occur depending upon the contaminants and oxidizing agents used.
- The process is not cost-effective for high contaminant concentrations because of the large amounts of oxidizing agent required.
- Oil and grease in the media should be minimized to optimize process efficiency.

Cost:

Estimated costs range from \$190 to \$660 per cubic meter (\$150 to \$500 per cubic yard).

Additional cost information can be found in the Hazardous, Toxic, and Radioactive Wastes (HTRW) Historical Cost Analysis System (HCAS) developed by Environmental Historical Cost Committee of Interagency Cost Estimation Group.

Containment

Containment measures are often performed to prevent, or significantly reduce, the migration of contaminants in soils or ground water. Containment is necessary whenever contaminated materials are to be buried or left in place at a site. In general, containment is performed when extensive subsurface contamination at a site precludes excavation and removal of wastes because of potential hazards and/or unrealistic cost.

The main advantage of containment methods is that they can prevent further migration of contaminant plumes, and allow for contaminant reduction at sites where the source is undetermined, inaccessible, or where long term remedial actions are being developed. Unlike ex situ treatment groups, containment does not require excavation of contaminated soils, which leads to increased costs from engineering design of equipment, possible permitting, and material handling. However, these treatments require periodical inspections for leaks, ponding of liquids, and corrosion. Additionally, ground water monitoring wells, associated with the treatments, need to be periodically sampled and monitored.

Applicability:

Slurry walls contain the ground water itself, thus treating no particular target group of contaminants. They are used to contain contaminated ground water, divert contaminated ground water from drinking water intake, divert uncontaminated ground water flow, and/or provide a barrier for the ground water treatment system.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Most of the approaches involve a large amount of heavy construction.
- The technology only contains contaminants within a specific area.
- Soil-bentonite backfills are not able to withstand attack by strong acids, bases, salt solutions, and some organic chemicals. Other slurry mixtures can be developed to resist specific chemicals.
- There is the potential for the slurry walls to degrade or deteriorate over time.
- Use of this technology does not guarantee that further remediation in the future may not be necessary.

Cost:

Costs likely to be incurred in the design and installation of a standard soil-bentonite wall in soft to medium soil range from \$540 to \$750 per square meter (\$5 to \$7 per square foot) (1991 dollars). These costs do not include variable costs required for chemical analyses, feasibility, or compatibility testing. Testing costs depend heavily on site-specific factors.

Factors that have the most significant impact on the final cost of soil-bentonite slurry wall installation include:

- Type, activity, and distribution of contaminants.
- Depth, length, and width of wall.
- Geological and hydrological characteristics.
- Distance from source of materials and equipment.
- Requirements for wall protection and maintenance.
- Type of slurry and backfill used.
- Other site-specific requirements as identified in the initial site assessment (e.g., presence of contaminants or debris).
- Planning, permitting, regulatory interaction, and site restoration.

Additional cost information can be found in the Hazardous, Toxic, and Radioactive Wastes (HTRW) Historical Cost Analysis System (HCAS) developed by Environmental Historical Cost Committee of Interagency Cost Estimation Group.

Excavation/Dredging and Disposal

Contaminated material is removed and transported to permitted off-site disposal facilities or stored into a designated upland area. In case of off site disposal some pretreatment of the contaminated media usually is required in order to meet land disposal restrictions.

Confined disposal facilities (CDFs) are engineered structure enclosed by dikes and designed to retain dredged materials. A CDF may have a large cell for material disposal, and adjoining cells for retention and decantation of turbid, supernatant water. A variety of linings have been used to prevent seepage through the dike walls. The most effective are clay or bentonite-cement slurries, but sand, soil, and sediment linings have also been used.

Location and design are two important CDF considerations. Terms to consider in the location of a CDF are the physical aspects (size, proximity to a navigable waterway), the design/construction (geology/hydrology), and the environmental (current use of the area, environmental value, and environmental effects). The primary goal of a CDF design is minimization of contaminant loss. Caps are the most effective way to minimize contaminant loss from CDFs, but selection of proper liner material is also an important control on CDFs. Finally, CDFs require continuous monitoring to ensure structural integrity.

Operation and maintenance duration lasts as long as the life of the facility.

Dredging. In case of impacted sediment dredging and upland disposal is a possible remedy. Dredging will remove the contaminated material, and removal tends to be a more controlled remedy than in-water containment. Furthermore, without prior dredging, capping in the marina is not possible because the cap would interfere with and be damaged by navigation.

The impacted sediment will be dredged. The depth and extent of dredging will be determined based upon information obtained from ESA and future site investigation. Confirmatory sampling will also be required to verify that contaminated sediments have been adequately removed. If all of the contaminated sediments cannot be practicably dredged then the remaining contaminated sediment areas will be capped in place to the extent practicable. The dredged material will be contained upland in an designated area or a landfill. In case of disposal in a designated upland area, proper design should be considered by site grading and the installation of a low-permeability soil cap that will contain the sediments dredged from the Bay.

Material dredged from the Bay may be contained temporarily on the upland area and dewatered. Dewatered sediments will be permanently contained in an upland location that will be determined. Sediments contained in the upland location will be permanently covered with the low-permeability cap being installed across the area. Effluent derived from the dewatering of dredged material will be discharged into the Bay in accordance with applicable water quality requirements. The specific sediment dewatering methods and requirements for management of

discharges from dewatering effluent shall be defined prior to remedial design and implemented during construction.

Applicability:

Excavation/Dredging and off-site disposal is applicable to the complete range of contaminant groups with no particular target group. Excavation and off-site by relocating the waste to a different (and presumably safer) site.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility with the required permit(s) will affect cost.
- Depth and composition of the media requiring excavation must be considered.
- Transportation of the soil through populated areas may affect community acceptability.
- Disposal options for certain waste (e.g., mixed waste or transuranic waste) may be limited. There is currently only one licensed disposal facility for radioactive and mixed waste in the United States.
- Contaminants can potentially migrate from CDF from several pathways, including effluent discharge to surface water, rainfall surface runoff, leachate into ground water, volatilization to the atmosphere, and like uptake.
- CDFs can develop odor problems as well as mosquito and insect problems without proper design and maintenance.

Performance Data:

Excavation and off-site disposal is a well-proven and readily implementable technology. Prior to 1984, excavation and off-site disposal was the most common method for cleaning up hazardous waste sites. Excavation is the initial component in all ex situ treatments.

The rate of excavation depends on a number of factors, including the number of loaders and trucks operating. The excavation of 18,200 metric tons (20,000 tons) of contaminated soil would typically require about 2 months. Disposal of the contaminated media is dependent upon the availability of adequate containers to transport the hazardous waste to a permitted facility.

CERCLA includes a statutory preference for treatment of contaminants, and excavation and off-site disposal is now less acceptable than in the past. The disposal of hazardous wastes is governed by RCRA (40 CFR Parts 261-265), and the U.S. Department of Transportation (DOT) regulates the transport of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E 8876).

DOE has demonstrated a cryogenic retrieval of buried waste system, which uses liquid nitrogen (LN₂) to freeze soil and buried waste to reduce the spread of contamination while the buried material is retrieved with a series of remotely operated tools. Other excavation/retrieval systems that DOE is currently developing include a remote excavation system, a hydraulic impact end effector, and a high pressure waterjet dislodging and conveyance end effector using confined sluicing.

Cost:

Cost estimates for excavation and disposal range from \$300 to \$510 per metric ton (\$270 to \$460 per ton) depending on the nature of hazardous materials and methods of excavation. These estimates include excavation/removal, transportation, and disposal at a RCRA permitted facility. Additional cost of treatment at disposal facility may also be required. Excavation and off-site disposal is a relatively simple process, with proven procedures. It is a labor-intensive practice with little potential for further automation. Additional costs may include soil characterization and treatment to meet land ban requirements.

Additional cost information can be found in the Hazardous, Toxic, and Radioactive Wastes (HTRW) Historical Cost Analysis System (HCAS) developed by Environmental Historical Cost Committee of Interagency Cost Estimation Group.

Capping

Capping can be used to:

- Minimize exposure on the surface of the impacted waste media.
- Prevent vertical infiltration of water into wastes that would create contaminated leachate.
- Contain waste while treatment is being applied.
- Control dispersion and erosion of the impacted media.
- Create a land surface that can support vegetation and/or be used for other purposes.

Capping is the most common form of remediation because it is generally less expensive than other technologies and effectively manages the human and ecological risks associated with a remediation site.

The design of caps is site specific and depends on the intended functions of the system. Caps can range from a one-layer system of vegetated soil to a complex multi-layer system of soils and geosynthetics. In general, less complex systems are required in dry climates and more complex systems are required in wet climates. The material used in the construction of caps includes low-permeability and high-permeability soils and low-permeability geosynthetic products. The low-permeability materials divert water and prevent its passage into the waste. The high permeability materials carry water away that percolates into the cap. Other materials may be used to increase slope stability.

The most critical components of a cap are the barrier layer and the drainage layer. The barrier layer can be low-permeability soil (clay) and/or geosynthetic clay liners (GCLs). A flexible geomembrane liner is placed on top of the barrier layer. Geomembranes are usually supplied in large rolls and are available in several thickness (20 to 140 mil), widths (15 to 100 ft), and lengths (180 to 840 ft). The candidate list of polymers commonly used is lengthy, which includes polyvinyl chloride (PVC), polyethylenes of various densities, reinforced chlorosulfonated polyethylene (CSPE-R), polypropylene, ethylene interpolymer alloy (EIA), and many newcomers. Soils used as barrier materials generally are clays that are compacted to a hydraulic conductivity no greater than 1×10^{-6} cm/sec. Compacted soil barriers are generally installed in 6-inch minimum lifts to achieve a thickness of 2 feet or more. A composite barrier uses both soil and a geomembrane, taking advantage of the properties of each. The geomembrane is essentially impermeable, but, if it develops a leak, the soil component prevents significant leakage into the underlying waste.

For facilities on top of putrescible wastes, the collection and control of methane and carbon dioxide, potent greenhouse gases, must be part of facility design and operation.

Asphalt/Concrete Cap: The most effective single-layer caps are composed of concrete or bituminous asphalt. It is used to form a surface barrier between impacted media and the environment. An asphalt concrete cap would reduce leaching through the landfill into an adjacent aquifer.

RCRA Subtitle C Cap: The RCRA C multi layered cap is a baseline design that is suggested for use in RCRA hazardous waste applications. These caps generally consist of an upper vegetative (topsoil) layer, a drainage layer, and a low permeability layer which consists of a synthetic liner over 2 feet of compacted clay. The compacted clay liners are effective if they retain a certain moisture content but are susceptible to cracking if the clay material is desiccated. As a result alternate cap designs are usually considered for arid environments.

RCRA Subtitle D Cap: RCRA Subtitle D requirements are for non-hazardous waste landfills. The design of a cap for a RCRA Subtitle D facility is generally a function of the bottom liner system or natural subsoils present. The cover must meet the following specifications:

- The material must have a permeability no greater than 1×10^{-5} cm/s, or equivalent permeability of any bottom liner or natural subsoils present, whichever is less.
- The infiltration layer must contain at least 45 cm of earthen material.
- The erosion control layer must be at least 15 cm of earthen material capable of sustaining native plant growth.

Alternative design can be considered, but must be of equivalent performance as the specifications outlined above. All covers should be designed to prevent the "bathtub" effect. The bathtub effect occurs when a more permeable cover is placed over a less permeable bottom liner or natural subsoil. The impacted media then fills up like a bathtub.

Applicability:

Caps may be temporary or final. Temporary caps can be installed before final closure to minimize generation of leachate until a better remedy is selected. They are usually used to minimize infiltration when the underlying waste mass is undergoing settling. A more stable base will thus be provided for the final cover, reducing the cost of the post-closure maintenance. Caps also may be applied to waste masses that are so large that other treatment is impractical. At mining sites for example, caps can be used to minimize the infiltration of water to contaminated tailings piles and to provide a suitable base for the establishment of vegetation. In conjunction with water diversion and detention structures, caps may be designed to route surface water away from the waste area while minimizing erosion.

Limitations:

Capping does not lessen toxicity, mobility, or volume of hazardous wastes, but does mitigate migration. Caps are most effective where most of the underlying waste is above the water table. A cap, by itself, cannot prevent the horizontal flow of ground water through the waste, only the vertical entry of water into the waste. In many cases caps are used in conjunction with vertical walls to minimize horizontal flow and migration. The effective life of waste components (including cap) can be extended by long-term inspection and maintenance. Vegetation, which has a tendency for deep root penetration, must be eliminated from the cap area. In addition, precautions must be taken to assume that the integrity of the cap is not compromised by land use activities.

Cost:

Caps are generally the least expensive way to manage the human health and ecological risks effectively. Rough industry costs are \$175k/acre for RCRA Subtitle D, and \$225k/acre for RCRA Subtitle C.

Additional cost information can be found in the Hazardous, Toxic, and Radioactive Wastes (HTRW) Historical Cost Analysis System (HCAS) developed by Environmental Historical Cost Committee of Interagency Cost Estimation Group.